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13. ABSTRACT *(Maximum 200 words)*

This report describes several infrastructure development projects implemented within the School of Engineering and Architecture. The major objectives were to motivate and prepare students and teachers at the pre-college level, to strengthen the quality of engineering education at the college level, and to produce high caliber graduates who would pursue graduate studies. Under the pre-college category, we strengthened and expanded the already established program for 9th through 12th graders and reinforced linkages with selected middle schools of Alabama. In the college component, we implemented innovative freshmen level course modules to be delivered through the use of modern multi-media technologies and reinforced students' preparation with the help of a comprehensive learning resources center. This approach substantially increased not only the retention rate but also the quality of the graduates produced. The third major component of the grant addressed issues dealing with the graduate school pipeline. We identified potential graduate students early in their undergraduate years and involved them in research and provided them with adequate preparation for graduate studies. Financial support in the form of fellowships provided fellowships for African-American graduate students at the master's degree level.

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A Report

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INFRASTRUCTURE SUPPORT IN ENGINEERING A T TUSKEGEE UNIVERSITY GRANT

Submitted to

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By

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ABSTRACT

The School of Engineering and Architecture at Tuskegee University ranks among the largest producers of talented and well rounded African-American engineers in the country. The school has distinguished itself as a leader in offering innovative recruitment and retention programs for high school students in the region and in the nation.

This report described several infrastructure development projects implemented within the School of Engineering and Architecture. The major objectives were to motivate and prepare students and teachers at the pre-college level, to strengthen the quality of engineering education at the college level and to produce high caliber graduates who would pursue graduate studies.

Under the pre-college category, we strengthened and expanded the already established programs for 9th through 12th graders and reinforced linkages with selected middle schools of Alabama.

In the college component we implemented innovative freshmen level course modules to be delivered through the use of modern multimedia technologies and reinforced students' preparation with the help of a comprehensive learning resources center. This approach substantially increased not only the retention rate but also the quality of the graduates produced.

The third major component of the grant addressed issues dealing with the graduate school pipeline. We identified potential graduate students early in their undergraduate years and involved them in research and provide them with adequate preparation for graduate studies. Financial support in the form of fellowship was also to provided fellowships for African-American graduate students at the master's level.

1. INTRODUCTION

Several recent studies have predicted an acute shortage of properly trained manpower in the fields of science and engineering in the next decade. This is due to the fact that the relative number of high school students who elect studies in science and mathematics courses, which prepare them for science and engineering studies at the college level, is decreasing. The net result of this situation is that fewer students are entering and graduating in science and engineering at the college level and even fewer are going on to graduate studies. Moreover, due to changes in demographics, it is clear that an increasing number of women and minority students need to be attracted to these programs to maintain the desired manpower level in the engineering profession.

The educational institutions in the United States face a major challenge of preparing the future scientists and engineers. Recognizing this, the engineering school at Tuskegee University has been involved in infrastructure development programs designed to ensure that an adequate supply of qualified minority and women technical manpower is available. The curriculum development in engineering at Tuskegee University was supported by the National Science Foundation (NSF) over a five-year period through the National Engineering Education Coalition program. The coalition was a consortium of eight universities, which included Cornell, Stanford and University of California at Berkeley. The development of the other aspects of the infrastructure at the engineering school has been going on for some time through a wide range of activities, albeit on an ad hoc basis as and when the funds could be raised for the individual programs.

The grant from the Army Research Office provided substantial and sustained funding over five years, so that the entire spectrum of the infrastructure development programs could be implemented simultaneously and their effect on the students could be fully assessed. The major objectives of the grants were to motivate and prepare students and teachers at the pre-college level, to strengthen the quality of engineering education at the college level and to produce high caliber graduates some of who could pursue graduate studies. These objectives were accomplished by:

- Stimulating the interest of minority students in science and mathematics while they were at the middle and high school levels.
- Strengthening the capabilities of teachers of minority students in science and mathematics at the middle and high school levels.
- Improving undergraduate educational experiences of students of engineering by delivering quality education, thus enhancing student interest and understanding.
- Providing research experiences for undergraduate students, which encouraged the pursuit of graduate degrees.
- Providing financial support for graduate studies.
- Establishing an alliance among selected school systems and universities. secure further support for the infrastructure development programs.

Tuskegee University's strategic plan includes strengthening the engineering infrastructure to substantially increase enrollment in engineering disciplines and the number of graduates pursuing advanced degrees The objectives of the grant therefore were consistent with those of the University.

2. PROGRAM IMPLEMENTATION

The infrastructure development program proposed to ARO was divided into three components as shown in Fig. 1. The components were: 1) Pre-College Programs, 2) Enrichment and Retention and 3) Graduate School Pipeline. The pre-college programs involve education and training activities for students in middle and high schools so that they could be better prepared academically to enter the science and engineering disciplines. While these students are in the engineering school, they must receive not only quality education but also the appropriate support services. This was accomplished by the enrichment and retention components. Finally, the graduate school pipeline components were designed to provide information, encourage students and provide financial support to move on to graduate studies at the master's and doctoral levels. Details of the activities carried under the infrastructure development are presented in this section.

A. Pre-College Programs

The Pre-College Program supported by the DoD grant are shown in figure 2.

1. **Summer Enrichment Program** for 5th-8th grade: This program offered enrichment courses in mathematics, science and computer usage to selected students of grades 5 through 8. The duration of the program was four weeks. The classes were of 3-hour duration per day (1 hour in mathematics, 1 hour in computer usage and 1 hour in science). There were 20 students per grade. This program was resident at the respective school systems and regular school teachers were involved in teaching. The school systems provide classrooms, computers and supervision. The program was offered in three school systems in Alabama; Tuskegee Institute High, Tuskegee, AL, Opelika High, Opelika, AL and Parker High, Birmingham, AL, 240 students were affected by this program each year.

2. **Pre-Freshman Enrichment I&II (PREP I & II):** This program was offered for students of two local high schools who completed the 9^{th} and 10^{th} grades, respectively. Instruction in mathematics, biology, chemistry, physics and engineering graphics was provided to the students. Engineering graphics was taught to the students of PREP I and computer programming was taught to the students of PREP II program. Laboratory sessions were designed to provide students with experience in experimentation, report writing and problem solving. The lectures were delivered by Tuskegee University faculty. The students also attended weekly guest lectures delivered by Tuskegee University alumni.

3. **Saturday Academy**: This program was offered for 9th to 12th grade students attending local high schools. Classroom type sessions were held for 120 students on the Tuskegee University campus on Saturdays (9 am to 12 pm) throughout the year when the schools

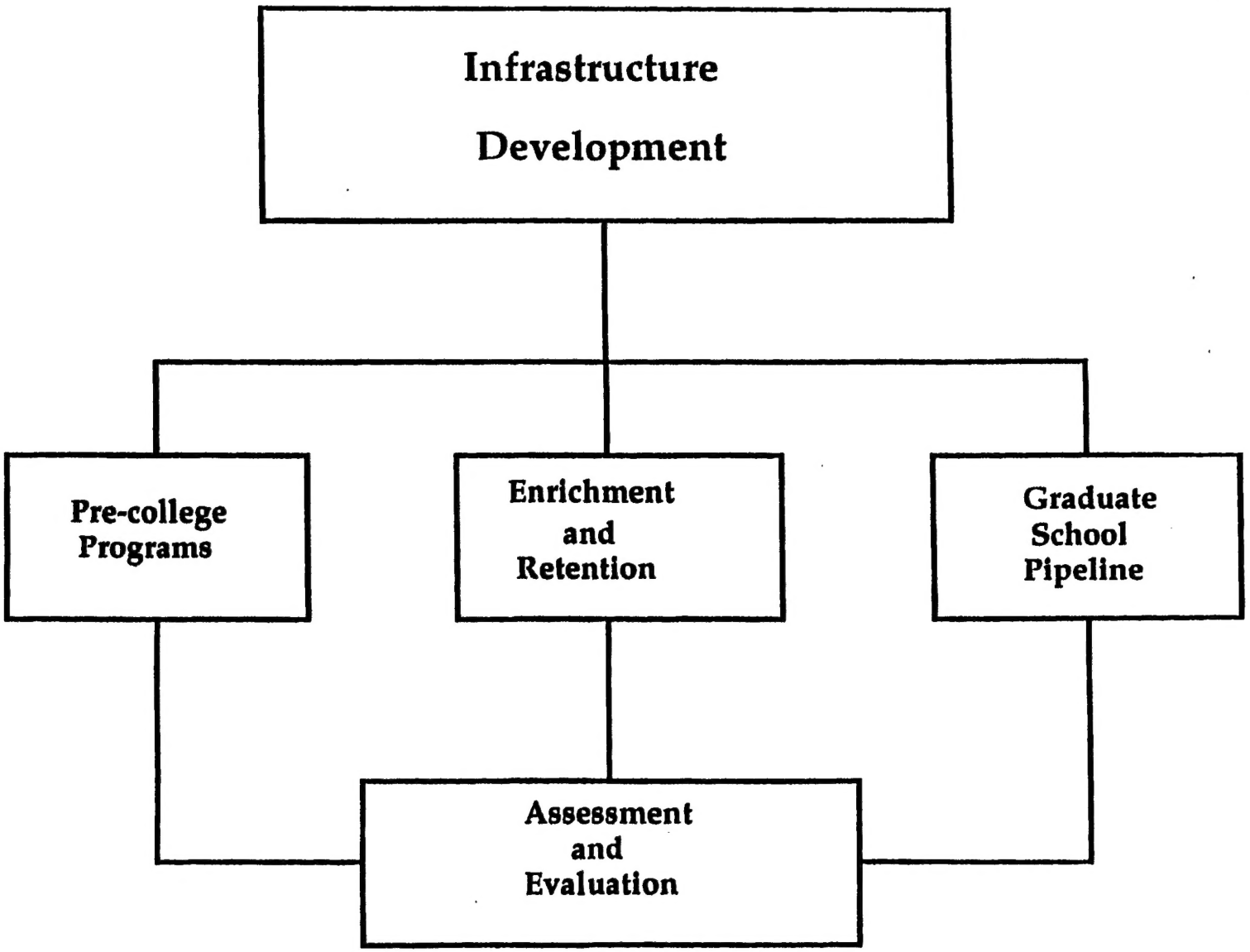

Fig. 1. Major Infrasturcture Components

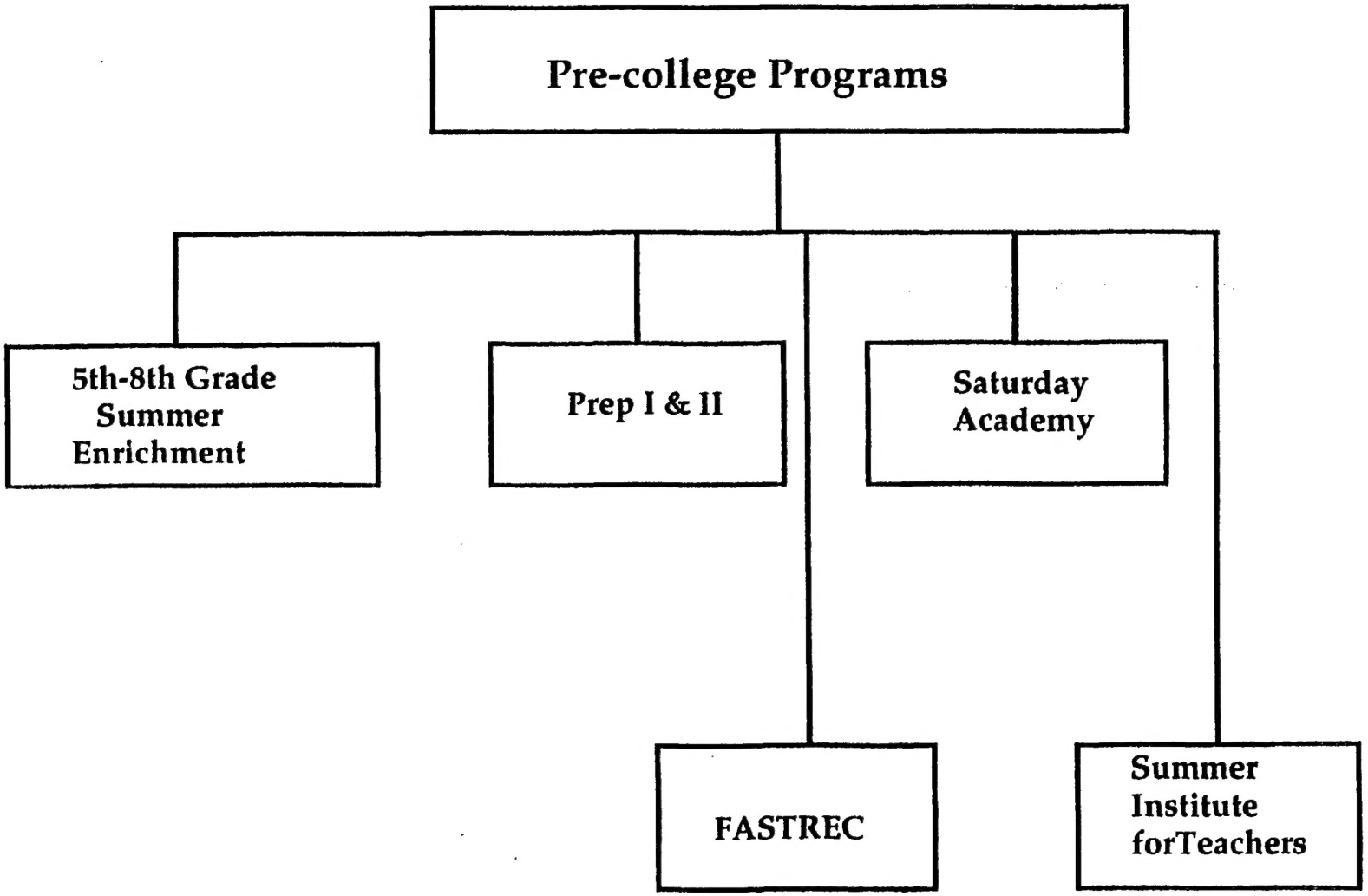

Fig.2. Pre-College Programs

were in session. This program was designed to help students with their preparation in science and mathematics courses so that they could qualify for admission in science and engineering curricula at the college level. The materials provided in these sessions were prepared and delivered by the faculty of chemistry, engineering, mathematics and physics in consultation with their counterparts in the high schools. In addition, tutorial services were provided in the afternoons (Monday through Friday, 3 pm to 6 pm) for students who need assistance.

4. **Freshman Accelerated Start-up and Training for Retention in the Engineering Curricula (FASTREC)**: Students completing their senior year in high school were invited to attend this program. It was an 8 week summer program offered at Tuskegee University for high school graduates who were about to enter college. FASTREC has become one of the most effective means of identifying and recruiting minority students to study engineering at Tuskegee University. The selection of students for this program was based on their SAT or ACT scores, high school grade point average, rank in class, and recommendation of school officials. Students pursued an intensive program of study in freshman orientation, one course in mathematics and one course in engineering graphics, computer programming or environmental science. Up to seven semester credit hours were awarded toward the BS degree in engineering. The students also attended guest lectures, seminars and field trips.

5. **Summer Institute for Teachers**: In this program, 20 teachers of science and mathematics were invited to Tuskegee University for one week to acquaint them with the engineering profession. The program covered lectures and demonstrations in topics covering science, mathematics and engineering, hands-on experience in the use of computers for classroom delivery and a trip to a modem engineering manufacturing facility.

B. **Enrichment and Retention**:

The enrichment and retention program was composed of the following:
1) Freshmen Design and Laboratory Experience
2) Courseware Preparation Studio and Delivery System
3) Learning Resources Center
4) Research Experience for Undergraduates

These are shown in Fig. 3. The engineering school was already involved in a small way with the freshmen design experience and courseware preparation studio and delivery system through its participation in the Engineering Education Coalition and Research Experience for Undergraduates with support from NSF. We expanded these programs and established a learning resources center to increase the student retention rate.

1. **Freshmen Design and Laboratory Experience**: Most of the freshmen find the first year of the engineering program very difficult and the curricula unattractive as they are required to take courses heavily oriented towards liberal arts, mathematics and science. To counteract this, we developed several highly innovative and challenging freshmen design and laboratory modules

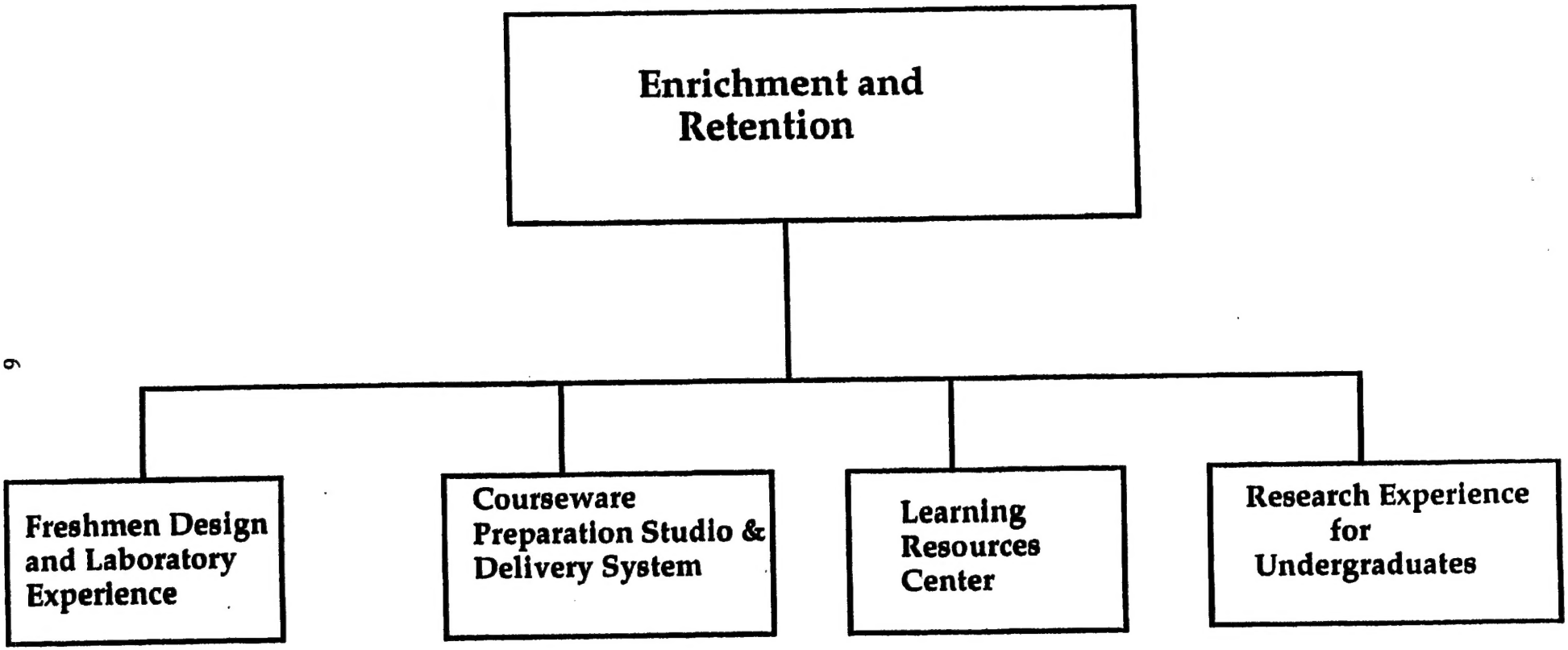

Fig.3. Enrichment and Retention Components

for each of our four engineering programs. The modules offered an early exposure of design and laboratory experience to the students. These experiences provided an opportunity for the students to interact with the faculty from their chosen disciplines during the freshmen year. The design modules included simple design problems relevant to the student's major area which illustrated the concepts behind the design processes, namely, problem identification, formulation of ideas and solution and analysis and execution of the design. A freshman level environmental sciences laboratory was also developed for students desiring to have a laboratory experience early in their studies. Environmental science has become a major area of study and it is relevant to all fields of engineering. Students enrolled in this course were able to meet the science elective requirement of their respective curricula.

2. **Courseware Preparation Studio and Delivery System**: It is generally agreed that the current method of teaching is becoming outdated as new multimedia technologies suitable for classroom deliveries are becoming available at a reasonable cost. Much of the activities of the Engineering Education Coalition, of which Tuskegee University is an active member, involved revising the engineering curricula suitable for delivery using the modern multimedia technologies. Although, the Coalition's activities do involve further development of multimedia technologies, databases and computer networking, very little money has been provided for development of courseware preparation studio and acquisition of the hardware related to the delivery of the course material. Therefore relevant multimedia technology hardware for development of a courseware preparation studio and the courseware delivery system were acquired. With these in place, faculty were able to prepare multimedia courseware modules.

3. **Learning Resources Center**: An alarmingly high drop-out rate exists in the nation's engineering programs, particularly, during the freshmen and sophomore years. In spite of many remedial classes and activities that are in place at the college level, the drop-out rate remains high. To reduce the drop-out rate, Tuskegee University established a learning resources center where students' progress could be monitored and accelerated by providing tutorial and counseling support. The learning resources center is envisioned to encompass two complementary functions: 1) a staff function where students' progress is monitored from the time they enter as freshmen and retention data is collected and evaluated and 2) a learning function where students gather in the evening for studies and have access to the modular curricular courseware on the multimedia platform. Fifteen personal computers were provided per year and loaded with the modular curricular courseware. Towards this end, a 1000 ft^2 room was converted to the learning resources center. A group of tutors selected from the upper classmen and several graduate students provided tutorial assistance. The learning resources center is accessible to the students throughout the day and well into the late evening.

4. **Research Experience for Undergraduates**: Over the last five years, about 30 undergraduate students have been associated with research programs. The research experiences have been found to be extremely successful as one-third of the participants have gone on to graduate school. In these programs the students spend 10 weeks in summer on funded research projects. While participating in the research activities, each undergraduate student is paired with one graduate student. The students were also required to enroll in a 3-credit hour Research course, which was counted as a technical elective. An oral presentation of the research work is required

to obtain a passing grade in the course. In view of the success of the program, we expanded it by including ten more students.

C. Graduate School Pipeline

The graduate school pipeline program was divided into the following three components. These are:

1) Preparation for Graduate School
2) M. S. Program
3) Faculty Development

The graduate school pipeline was designed to provide information, encouragement and financial support to students to continue study at the graduate level and to support faculty development programs to keep the faculty abreast of changes in technology.

1. **Preparation for Graduate School**: Through this component of the program we provided monthly seminars to the students about opportunities in the graduate school. Speakers from government and industrial research laboratories were invited to make presentations about the facilities that are available to the students aspiring to be research scientists. Assistance was also provided in preparation for Graduate Record Examination.

2. **M. S. Program**: This component was designed to provide financial support to the minority students to study at the master's level at Tuskegee University. The Mechanical and Electrical Engineering Departments currently support approximately 40 students through basic budget and grants and contracts. The Chemical Engineering Department is going through the processes to establish a M. S. program. Financial support for 10 additional minority students was provided through this grant.

3. **Faculty Development**: We believe that the strength of the faculty is the single most critical element in the success of a university. Faculty members must keep abreast of the developments in their fields to provide quality education to their students. Hence, we made sure that opportunities were available for faculty development in engineering by providing study and research support to selected faculty.

5. MANAGEMENT AND TECHNICAL TEAM

Dr. Shaik Jeelani, Who was then the Associate Dean of the School of Engineering and Architecture, was responsible for the overall administration of the research project. He was specifically responsible for: (1) initiation, preparation and submission of all reports, subject to review by the appropriate authority of Tuskegee University and (2) monitoring of grant activities both programmatically and fiscally. He was guided by an advisory committee composed of the following:

1. Dr. William Lester -Provost, Tuskegee University (Chairperson)
2. Dr. Ollie Williamson -Dean of Arts and Sciences, Tuskegee University

3. Dr. Walter Hill -Dean of Agriculture and Home Economics, Tuskegee University
4. Dr. Noe Lozano -Associate Dean of Engineering, Stanford University
5. Dr. Howard Adams -Executive Director, GEM Inc.
6. Mr. Guy Vickers -Executive Director, SECME Tuskegee University Alumni:
7. Mr. Guy Dilworth -Executive Director, Naval Air Warfare System(Co-Chairperson)
8. Mr Aaron Henderson -Southern Bell
9. Mrs. Amanda Harris -NASA Branch Chief, Quality Assurance
10. Mr. Tony Draper -Hughes Aircraft Company

The projects under the Pre-College Programs was directed by Dr. S. Jeelani. He has over 18 years of experience at Tuskegee University in nurturing and developing many of the components that are presented here. He was assisted in this endeavor by an Assistant Director of Recruitment who was supported by several graduate and undergraduate students.

The Enrichment and Retention projects were managed by Dr. Pradosh Ray, Professor and Head, Mechanical Engineering Department. He has over 16 years experience in the pre-college programs assisting Dr. Jeelani. He also directed Tuskegee University's projects in the National Engineering Education Coalition.

The projects under the Graduate School Pipeline Program was directed by Dr. Jennie Patrick, 3M Eminent Scholar and Professor, Chemical Engineering Department.

The detailed budget and logistics of the project on a day-to-day basis were handled by Dr. J. Krishnagopalan, Associate Professor of Chemical Engineering.

The entire project was evaluated by Dr. A. M. S. Rao who is the Director of the Office of University Assessment and Evaluation. He has extensive experiences in this area and he worked directly with Dr. Jeelani to develop the necessary tools for assessing the individual components of the project and analyze the data.